Preoperative and intraoperative evaluation of diameter-reflux relationship of calf perforating veins in patients with primary varicose vein

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Objective: **Interruption of incompetent perforating veins (PVs) is important for varicose vein surgery. The purpose of this study was to evaluate the preoperative and intraoperative diameter-reflux relationship of PVs and to evaluate the accuracy of preoperative duplex scanning in patients with varicose vein.**
Methods: **Patients with primary varicose veins were retrospectively investigated. Diameters and reflux of PVs were evaluated before surgery with color flow duplex ultrasound scan (US). During operation, the incompetent PVs were defined as those that showed an outward spurt of blood flow from the stump of the PVs. The sensitivity and specificity of US in the detection of reflux of PVs were calculated. Competent versus incompetent vein diameters were compared with the Student *t* test and one-way analysis of variance.**
Results: **Three hundred twenty-four calf PVs were detected in 304 legs of 175 patients with varicose vein. Diameters of competent and incompetent PVs confirmed with intraoperative finding averaged 2.67 ± 1.10 mm (n = 28) and 3.28 ± 1.01 mm (n = 58), respectively, at the upper calf ($P = .012$), 2.85 ± 0.85 mm (n = 53) and 3.68 ± 0.94 mm (n = 137), respectively, at the lower calf ($p < .001$), and 2.67 ± 0.99 mm (n = 14) and 3.27 ± 0.66 mm (n = 22), respectively, at the posterior calf ($P = .036$). The overall sensitivity of detection of reflux with US was 87.7%, and the specificity was 75.3%. Diameters of true-incompetent PVs and false-incompetent PVs were 3.59 ± 0.94 mm (n = 199) and 3.31 ± 0.84 mm (n = 24), respectively ($P = .157$). Diameters of true-competent PVs and false-competent PVs were 2.61 ± 0.91 mm (n = 73) and 2.89 ± 0.82 mm (n = 28), respectively ($P = .158$).**
Conclusion: **Although the diameter of incompetent PVs was larger than that of competent PVs in both US and intraoperative findings, diameter measurement alone can not completely distinguish competent and incompetent PVs. The sensitivity and specificity of reflux obtained with US showed that the accuracy of preoperative duplex scanning to evaluate PV competency was not sufficient. (J Vasc Surg 2002;36:1225-30.)**

Various procedures have been performed for the treatment of varicose veins, including selective stripping, high ligation of the saphenous vein, sclerotherapy, and endoscopic perforator surgery.[1-4] Ligation of perforating veins (PVs) plays an important role in the treatment of varicose veins. Previous reports have suggested that PVs may contribute to venous hypertension and play an important role in the development of chronic venous insufficiency.[5,6] Therefore, ligation of PVs plays an important role in the treatment of varicose veins, and recently, subfascial endoscopic perforator surgery (SEPS) has developed.[4,7-9] Many methods have been used for the diagnosis of PV incompetence, including physical examinations, such as the Trendelenburg's and Perthes' tests, conventional phlebography, and color flow duplex ultrasound scan (US). Nowadays, US has taken the place of conventional phlebography as the gold standard for evaluation of the venous system.[2,10-15]

Preoperative diagnosis of whether the PV is competent or incompetent is not easy, and the accuracy of such diagnosis has not been well investigated. When PV ligation is avoided, more acceptable aesthetic results may be achieved. However, residual incompetent PVs may be associated with the recurrence of varicose veins. Some authors reported that a decreased diameter might be the key to estimating valvular function.[2,16] Sandri et al[17] reported that function of calf PVs is probably normal, abnormal but competent, incompetent, or severely incompetent for diameters in the 1.5-mm, 2.5-mm, 3.5-mm, and 4.5-mm ranges, respectively. In this study, we studied the diameter-reflux relationship of PVs with analysis of preoperative US and intraoperative findings.

PATIENTS AND METHODS

Three hundred twenty-four PVs in 175 patients who underwent surgery for varicose veins between November 1995 and December 2000 were retrospectively studied. According to the CEAP classification, varicose veins with congenital (E_C), thrombotic, and traumatic (E_S) causes were excluded, and only primary ones were included.[18] The median age was 55.1 years (range, 23 to 78 years), and 116 female and 59 male patients were included. According to

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Table I. Average diameters measured with preoperative US of competent and incompetent perforating veins in the calf diagnosed with US

	Diameter (mm)		
	Competent perforators	*Incompetent perforators*	P *value*
Upper calf	2.45 ± 0.91 (n = 29)	3.40 ± 1.00 (n = 57)	<.001
Lower calf	2.84 ± 0.89 (n = 53)	3.68 ± 0.92 (n = 137)	<.001
Posterior calf	2.64 ± 0.88 (n = 17)	3.40 ± 0.65 (n = 19)	.059

Table II. Average diameters measured with preoperative US of competent and incompentent perforating veins in the calf diagnosed during operation

	Diameter (mm)		
	Competent perforators	*Incompetent perforators*	P *value*
Upper calf	2.67 ± 1.10 (n = 28)	3.28 ± 1.01 (n = 58)	.012
Lower calf	2.85 ± 0.85 (n = 53)	3.68 ± 0.94 (n = 137)	<.001
Posterior calf	2.67 ± 0.99 (n = 14)	3.27 ± 0.66 (n = 22)	.036

the CEAP classification, 185 limbs were classification C_2 varicose veins, 55 were C_3 edema, 56 were C_4 significant skin change, one was C_5 healed ulceration, and seven were C_6 active venous ulceration. To evaluate the accuracy of preoperative diagnosis of competency in PVs, US was performed in a standing position in all patients for preoperative evaluation.

Standard US techniques were used to evaluate deep, superficial, and PVs.[2,10,15,19] Femoropopliteal veins were checked for thrombosis, chronic obstruction, or reflux with valvular insufficiency. In addition, greater and lesser saphenous veins were evaluated for the presence or absence of reflux. PVs were detected, and the locations of calf PVs were classified into three categories (upper calf, lower calf, and posterior calf). The diameters were measured on B-mode transverse projections at the crossing level of the fascia, and reflux was defined as a reverse flow lasting longer than 0.5 seconds with manual compression and release at the distal portion of the limb. We regarded any reverse flow during the procedure as reflux. A US scanner equipped with a 7.5-MHz transducer was used in all cases (LOGIC 500, GE Yokogawa Medical, Tokyo, Japan).

During the operation, stripping of long or short saphenous veins in combination with phlebectomy was performed first. Subsequently, PVs were disconnected from superficial venous systems at the suprafascial level via small incisions just above the PVs. A part of the wall of the disconnected PV that connects to the deep venous system was held with forceps. Incompetence of the PVs was evaluated with a squeeze-and-release maneuver of the lower extremity with the patient in the supine or prone position (bleed-back test). The PV was defined as incompetent if a spurt of blood was observed during the squeeze and release maneuver.[20]

Table III. Sensitivity and specificity of duplex US for detecting competency

Diameter	*Sensitivity*	*Specificity*
Less than 3 mm (n = 110)	69.1%	85.5%
More than 3 mm (n = 214)	93.6%	61.9%
Overall (n = 324)	87.7%	75.3%

Table IV. Comparison of diameters of perforating veins

	Diameter (mm)	P *value*
True incompetent (n = 199)	3.59 ± 0.94	.157
False incompetent (n = 24)	3.31 ± 0.84	
True competent (n = 73)	2.61 ± 0.91	.158
False competent (n = 28)	2.89 ± 0.82	

Average diameters of competent and incompetent PVs at the upper calf, the lower calf, and the posterior calf were represented as mean ± standard deviation. Statistical comparisons were performed with the Student *t* test and one-way analysis of variance. Differences with *P* values of less than .05 were considered to be significant.

RESULTS

We compared the average diameters of PVs in which the competency was judged with either preoperative US (duplex scan) (Table I) or surgical findings with bleed-back test (Table II). Table I shows the average diameters of PVs measured with preoperative US in the upper calf, the lower calf, and the posterior calf. Before surgery, the diameters of incompetent PVs were significantly larger than those of competent ones in the upper and lower calf. But for PVs in the posterior calf, the diameters of incompetent and competent PVs were not statistically different ($P = .059$; Table I). When we compared the diameter before surgery in each of three locations (ie, upper, lower, and posterior calf), preoperative US diagnosis of competency showed that diameters of incompetent and competent PVs at either the upper or the lower calf were significantly different. Diameters at the posterior calf were not statistically different ($P = .059$; Table I). On the other hand, the diagnosis of competency judged with surgical findings identified that the preoperative diameter measured with US of incompetent PVs was statistically larger than that of competent ones in all three locations (Table II). However, when we retrospectively analyzed the accuracy of the diagnosis with the results on the basis of Tables I and II, the diameters of true-competent (preoperatively competent and surgically competent) PVs and false-competent (preoperatively competent and surgically incompetent) PVs were not significantly

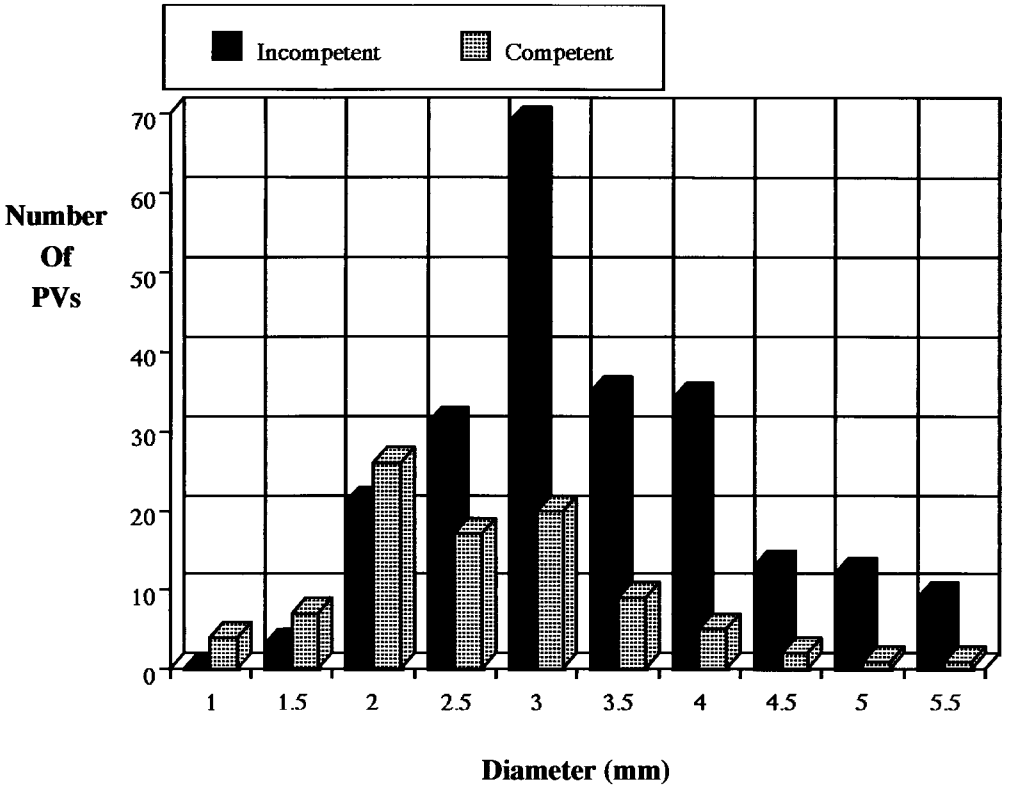

Fig 1. Histogram of competent and incompetent PVs obtained with intraoperative findings. Numbers of PVs were calculated for 0.5-mm interval.

different, nor were those of true-incompetent (preoperatively incompetent and surgically incompetent) PVs and false-incompetent (preoperatively incompetent and surgically competent) PVs. Therefore, diameter measurement alone could not differentiate either between true competent and false competent or true incompetent and false incompetent. However, subgroup analysis showed that in the lower calf, true-incompetent PVs (n = 123) were significantly larger than false-incompetent (n = 16) PVs ($P = 0.014$), suggesting that preoperative US measurement of diameter in lower calf PVs is likely to be useful for judging the competency. Also, no statistical difference was seen between the average diameters of competent and incompetent PVs among the clinical classifications (C_0 to C_6; data not shown). Table III shows the diameter-reflux relationship between US and intraoperative findings. In this study, the overall sensitivity of US was 87.8% (true positive, 199; and false positive, 28) and specificity was 75.3% (true negative, 73; and false positive, 24), which were compatible with results from a phlebography study. On the other hand, among the PVs with diameters of less than 3 mm, sensitivity was 69.1% (true positive, 38; and false positive, 17) and specificity was 85.5% (true negative, 47; and false positive, 8), respectively. However, the PVs that preoperative duplex scan identified to have small diameters (ie, less than 3 mm) and to be competent were not surgically exposed to perform the bleed-back test in many cases. Therefore, the sensitivity and specificity among the PVs with diameters of less than 3 mm might have been underestimated in this study. The mean diameters of true-positive (n = 217) and false-negative (n = 28) PVs were 3.53 ± 0.95 mm and 2.89 ± 0.82 mm, respectively ($P = .008$), and those of true-negative (n = 95) and false-positive (n = 24) ones were 2.77 ± 0.94 mm and 3.31 ± 0.84 mm, respectively ($P = .012$).

Fig 1 shows a histogram of competent and incompetent PVs. The median diameters of competent and incompetent PVs were 2.8 mm and 3.3 mm, respectively. Fig 2 shows the cumulative and interval reflux positive and negative predictive values in all calf PVs. A diameter of around 2 to 2.5 mm is the watershed of competent and incompetent PVs. Table IV shows the diameters of true-incompetent PVs, false-incompetent PVs, true-competent PVs, and false-competent PVs. Diameters of true-incompetent (n = 199), false-incompetent (n = 24), true-competent (n = 73), and false-competent (n = 28) PVs were 3.59 ± 0.94 mm, 3.31 ± 0.84 mm ($P = .157$), 2.61 ± 0.91 mm, and 2.89 ± 0.82 mm ($p = .158$), respectively.

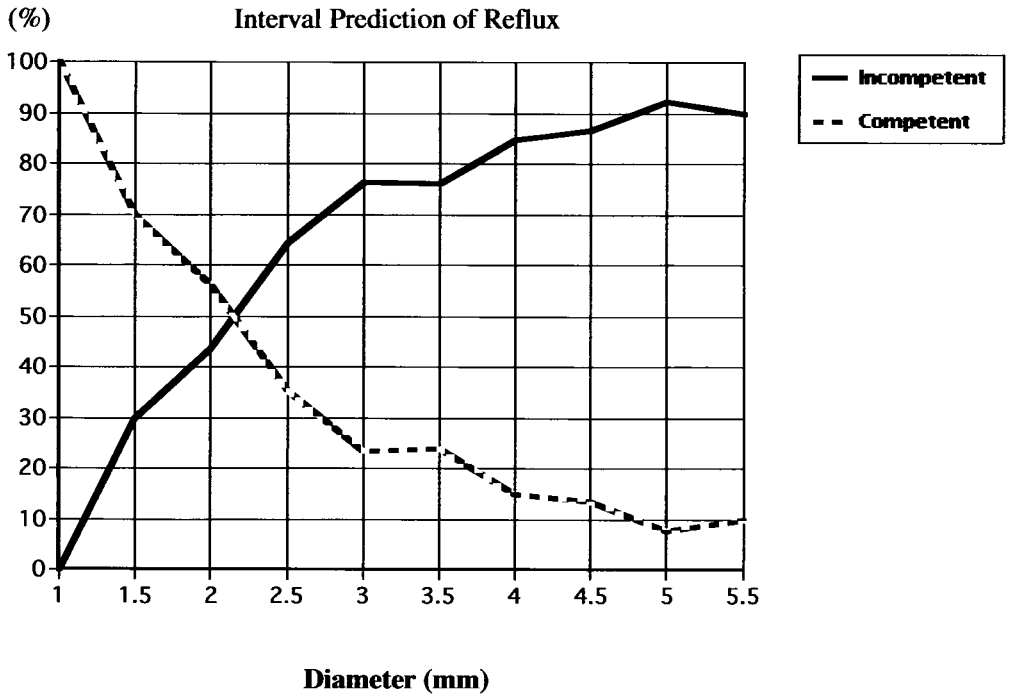

Fig 2. Interval predictive value for reflux in calf PVs. Interval positive and negative predictive values were calculated for 0.5-mm ranges around center value plotted.

DISCUSSION

Residual incompetent PVs after varicose vein operation might be associated with recurrence of varicose veins. Accurate preoperative diagnosis of incompetent PVs should thus enable a reduction of the number of operative wounds, leading to better aesthetics and earlier recovery.[5,21-24] Thus, SEPS is being widely used to disconnect PVs for aesthetic benefits and shortening of hospital stays. However, no standard guideline exists for the handling of PVs.[4,7-9,25]

In this study, we defined reflux of PV as reverse flow lasting longer than 0.5 seconds. No standard definition of reflux exists in PVs. van Bemmelen et al[15] reported that the reflux time of normal vein was less than 0.5 seconds in axial veins, and Labropoulos et al[22] defined a reflux more than 0.5 seconds of retrograde flow in PVs. Therefore, we adopted the figure of 0.5 seconds to define incompetent PVs.

The average diameter of competent PVs was around 2.7 mm, which was similar to the results of previous studies. However, the size was much larger than that of competent PVs measured in healthy volunteers (1.4 mm).[13] Labropoulos et al[26] reported that in patients with varicose vein the average diameter of competent PVs increased from 2 mm to 2.6 mm in proportion to the severity of clinical findings (C2 to C6). Therefore, an increased diameter does not always indicate the valvular dysfunction of PVs.

The mechanisms of valvular dysfunction of PVs are yet to be fully understood. One of the proposed mechanisms of the incompetency is the enlargement of diameter, in which PVs may serve as the reentry point of superficial blood flow to the deep venous system in patients with varicose vein. In this hypothesis, the valvular function may return to normal after surgery on the superficial system. This type of incompetent PV may not require surgical interruption if reflux of superficial system was interrupted. The other mechanism of incompetency is valvular dysfunction from irreversible valve damage. Irreversible valvular damage in PVs might be associated with recurrence of varicose veins after surgery on the superficial venous system. This type of incompetent PV may require surgical intervention for treatment of the superficial venous system. Therefore, preoperative identification of incompetent PVs as reversibly (pseudo) incompetent or irreversibly (true) incompetent would facilitate more precise operation. A few reports have indicated the importance of superficial reflux in the presence of incompetent PVs and pointed out that in the presence of postoperative deep venous reflux, incompetent PVs keep this incompetency. However, a method for the preoperative identification of true-incompetent PVs has yet to be established. We suspected that there may be a borderline diameter above which PVs become irreversibly incompetent (true incompetent).

However, it is difficult to predict the postoperative reversibility of incompetent PVs during operation. To evaluate the competency of PVs, US (duplex scanning) has so far been regarded as a useful tool. Although there has been a study with preoperative phlebography in which the accuracy of incompetent PV detection as judged with intraoperative findings was 90.4%,[27] we no longer routinely perform preoperative phlebography for patients with varicose vein. In this study, we used commonly used criteria of US for the determination of reflux in PVs, on the basis of a duration of reverse flow greater than 0.5 seconds.[17,26,28]

However, this maneuver was performed in the standing position, so the results might have been influenced by either saphenous vein reflux or deep vein reflux. In contrast, intraoperative tests with a squeeze-and-release maneuver of the distal portion of the extremity reflect the valvular competence of PVs because the superficial venous system was already disconnected and patients were tested in the supine or prone position. Therefore, we retrospectively evaluated the accuracy of the preoperative diagnosis of PVs with duplex scanning in comparison with intraoperative findings.

Sandri et al[17] used duplex US and reported that diameters larger than 3.5 mm were associated with reflux in the entire lower extremity in patients with C2 and C3. Moreover, Labropoulos et al[26] indicated that US diameters larger than 3.9 mm were reliably predictive of reflux among patients with skin change and ulcers. In this study, a diameter larger than 3.0 mm was 80.4% predictive of reflux. Therefore, we recommend operation for PVs with diameters larger than 3 mm when incompetent PVs need to be disconnected. However, we should acknowledge that there were also incompetent PVs of diameter no more than 2.0 mm on preoperative US measurement.

Preoperative US data showed that diameters of incompetent PVs were larger than competent ones in the upper calf and lower calf, similar to previous reports.[13,26] Moreover, in this study, we showed that incompetent PVs diagnosed at operation were also larger in size than competent ones when they were measured before surgery with US. These data indicate that preoperative measurement of diameter with US reflected the valvular competency of PVs as confirmed by operation to some extent. However, our analysis of false-positive and false-negative data revealed that diameters of false-incompetent and true-incompetent PVs were not significantly different and neither were the diameters of false-competent and true-competent PVs. These results indicated that there might be a limitation of measuring PV diameter with preoperative US to predict PV incompetency. These difficulties may make the idea of treating all the visible PVs rational with a technique such as SEPS. Application of SEPS for varicose vein surgery to treat all PVs may reduce the recurrence of varicose vein. A prospective study will be needed to predict the prognosis of PVs of various sizes.

In conclusion, the diameter of incompetent PVs, which we measured with preoperative US, was larger than that of competent ones. However, preoperative duplex scanning, when compared with intraoperative assessment, is not sufficient to distinguish incompetent from competent PVs, especially if the diameter of the vein is less than 3 mm.

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